



# Missouri Residential Energy Code Baseline Study

Review of Findings  
August 10, 2017



# Meeting Goals

- Discuss / Understand Study Findings
- Figure Out What We Do With All This Great Information

# Agenda

- Goals and Rationale of Study
- Key Item Analysis
- HVAC Sizing Analysis
- Implications of Analysis
- Opportunities for Improvement and Collaboration



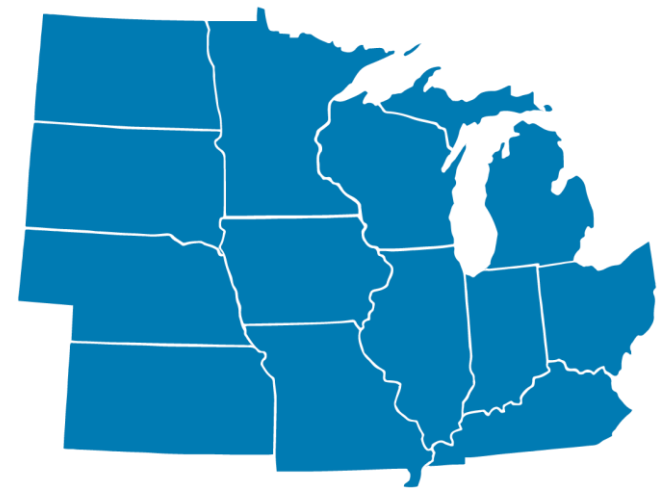
# About MEEA

## *The Trusted Source on Energy Efficiency*

We are a nonprofit membership organization with **160+ members**, including:

- Utilities
- Research institutions and advocacy organizations
- State and local governments
- Energy efficiency-related businesses

As the key resource and champion for energy efficiency in the Midwest, MEEA helps a diverse range of stakeholders understand and implement cost-effective energy efficiency strategies that provide economic and environmental benefits.



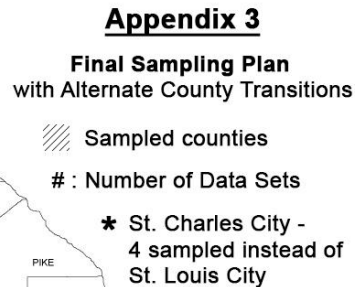
## Goals and Rationale of Study

- Comply with American Recovery and Reinvestment Act (ARRA) requirements
- Establish residential energy code compliance baseline.
- Determine potential energy savings from improved compliance.
- 1-year, statewide program focused on new, never occupied single-family homes
- Study was funded by DED/DE and lead by MEEA
- Data collection was conducted March – June 2016

# Goals and Rationale of Study

## *Sampling Plan*

- First step was to create a randomized sampling plan.
- Sampling distribution determined by random drawing of all permits from across the state (US census data).
- Minimum # of observations calculated by PNNL to ensure statistical significance of results.
- Used in-state project manager (Matt Belcher) to facilitate outreach and building recruitment.
- In-field data collection was performed by The Cadmus Group



# Goals and Rationale of Study

## *Data Collection Methodology*

- Each site visited only once (limited to single family homes)
- Observations were focused on key individual measures – not whole house
- 63 observations of each key measure (data sets)
- Locations for data collection were randomly selected and binned by county. Based on all permits issued statewide.
- Collected data from each site visit then inputted into Department of Energy designed database.
- Pacific Northwest National Laboratory (PNNL) analyzed the inputs and determined potential energy savings from improved compliance.

# Goals and Rationale of Study

## *Data Collection Key Items*

### Measures Collected at Insulation Stage

- Exterior wall insulation R-value and *quality*
- Foundation wall insulation R-value and *quality*
- Floor insulation R-value and *quality*
- Air sealing. Sealing on all penetrations in the building envelope including around windows, plumbing penetrations, utility penetrations, etc.
- Duct insulation R-value
- Window efficiency (U-factor)
- Window Solar Heat Gain Coefficient (SHGC)
- Air handler system information (e.g. furnace or heat pump)

# Goals and Rationale of Study

## *Data Collection Key Items*

### Measures Collected at Final Stage

- Ceiling insulation R-value and *quality*
- High efficacy lighting
- Envelope tightness -Air Changes per Hour at 50 Pascals (ACH50), aka Blower Door Test
- Duct Leakage - Cubic Feet per Minute at 25 Pascals (CFM25), aka Duct Blaster Test
- Additional information on the air handler and cooling system sizes

# Goals and Rationale of Study

## *Blower Door and Duct Blaster*



# Key Item Analysis

## Methodology

- Methodology was designed to determine the energy implications of non-compliance to a statistical significance
- Methodology provides a projection of savings associated with improved compliance
- Focused on components with largest direct impact on energy consumption (*key items*)
- Limited to new, never occupied, single family homes
- Actual observations must be made – no assumed or default values
- Ultimately 127 homes were visited to create the 63 data sets

# Key Item Analysis

## Methodology

- Key items with more than 15% non-compliant observations were selected for the savings analysis
- The six measures selected for savings analysis were, in order of greatest potential savings:
  - Basement Wall Insulation
  - Duct Leakage
  - High Efficacy Lighting
  - Above Grade Wall Insulation
  - Window U-Factor
  - Ceiling Insulation

## Key Item Analysis *Methodology*

- Energy simulations were conducted using EnergyPlus software
- Each non-compliant measure was analyzed separately
- Each non-compliant value was modeled individually
- All other components were maintained at the corresponding prescriptive code value, allowing for the savings potential associated with a key item to be evaluated in isolation

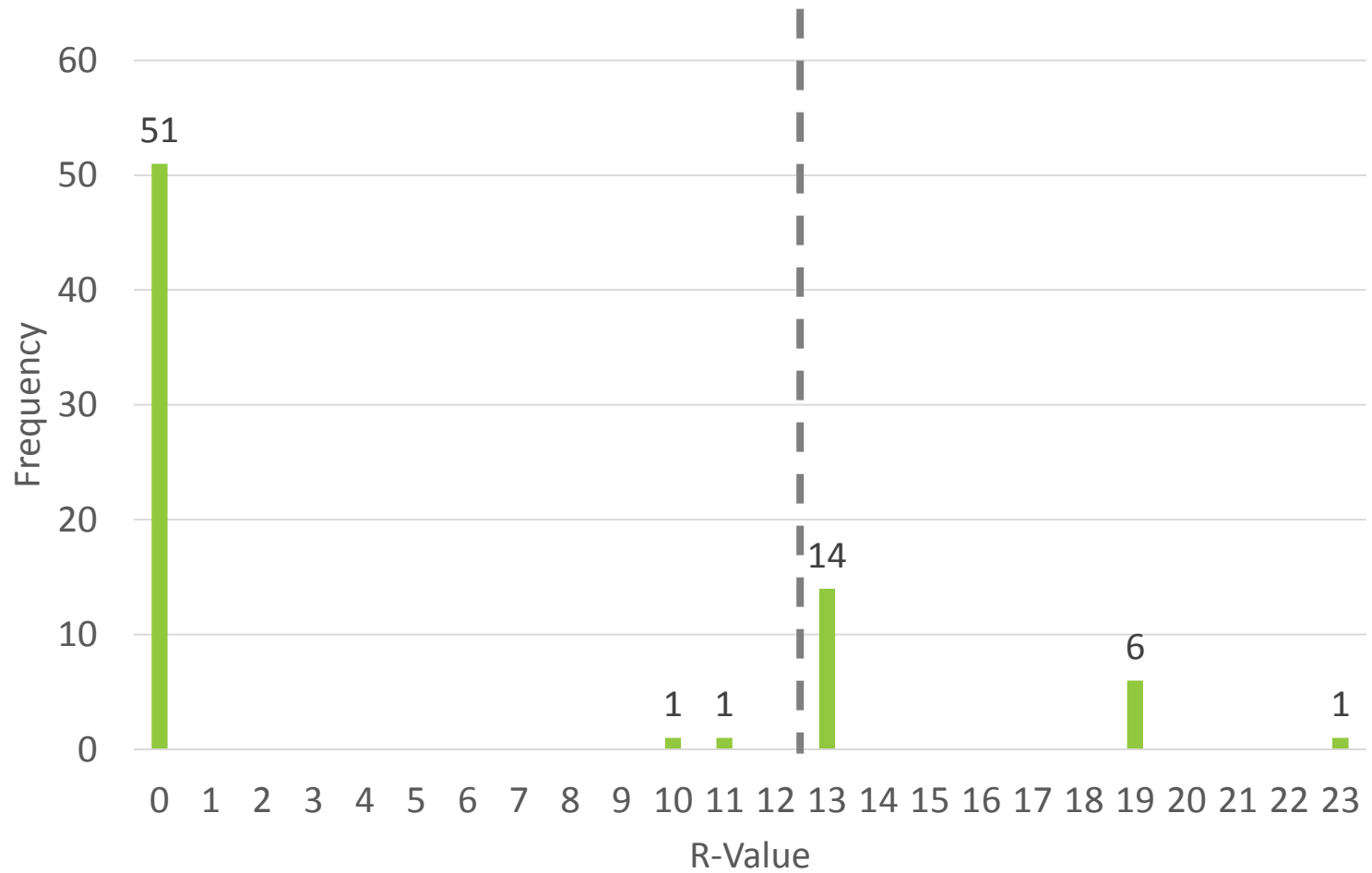
# Key Item Analysis

## Methodology

- Energy simulations were conducted using EnergyPlus software
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- Each non-compliant value was modeled individually
- All other components were maintained at the corresponding prescriptive code value, allowing for the savings potential associated with a key item to be evaluated in isolation
- All values on the following charts to the left of the vertical line are non-compliant values

# Basement Wall Insulation

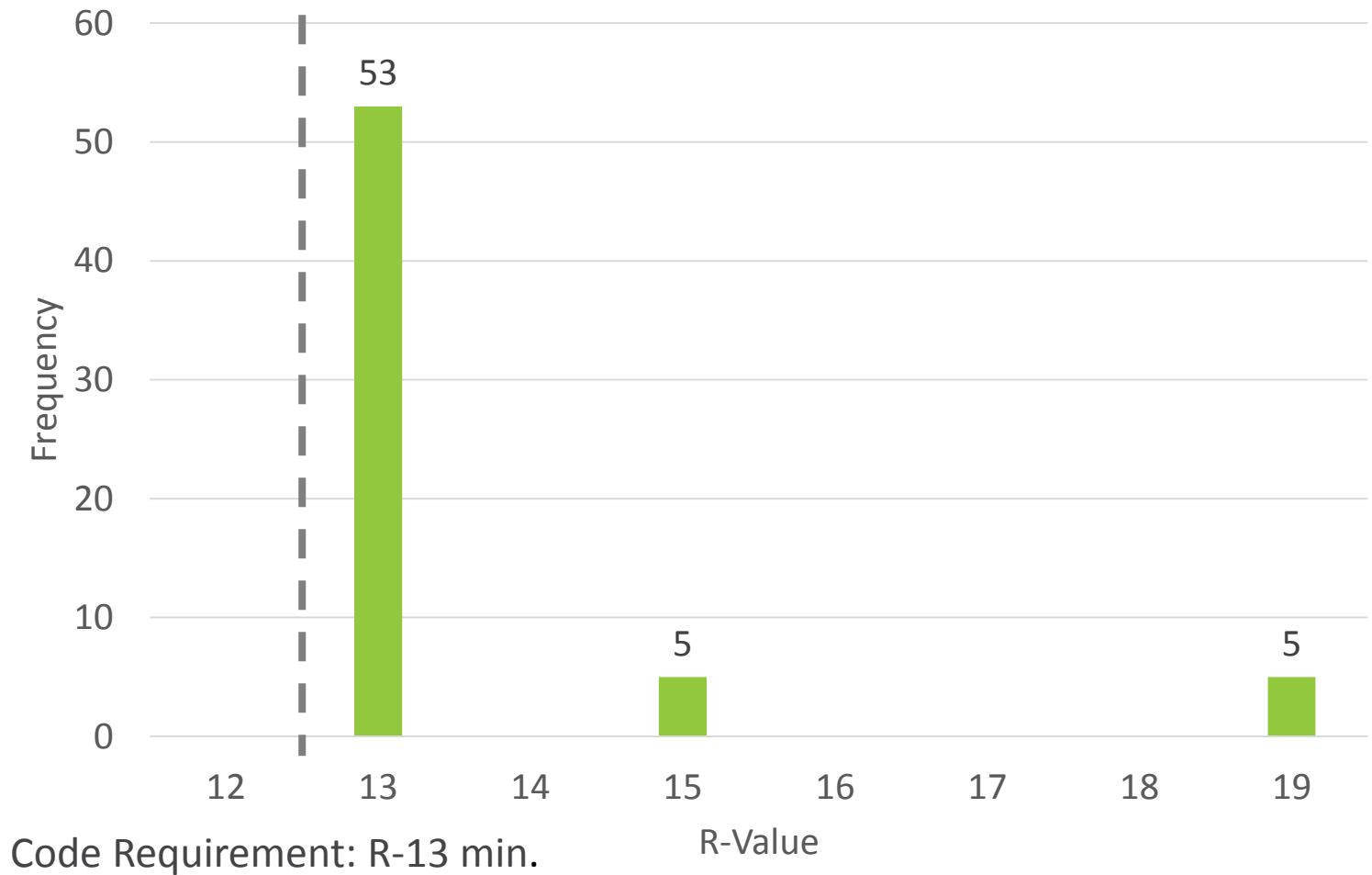
*R-Value*



Code Requirement: R-13 min.

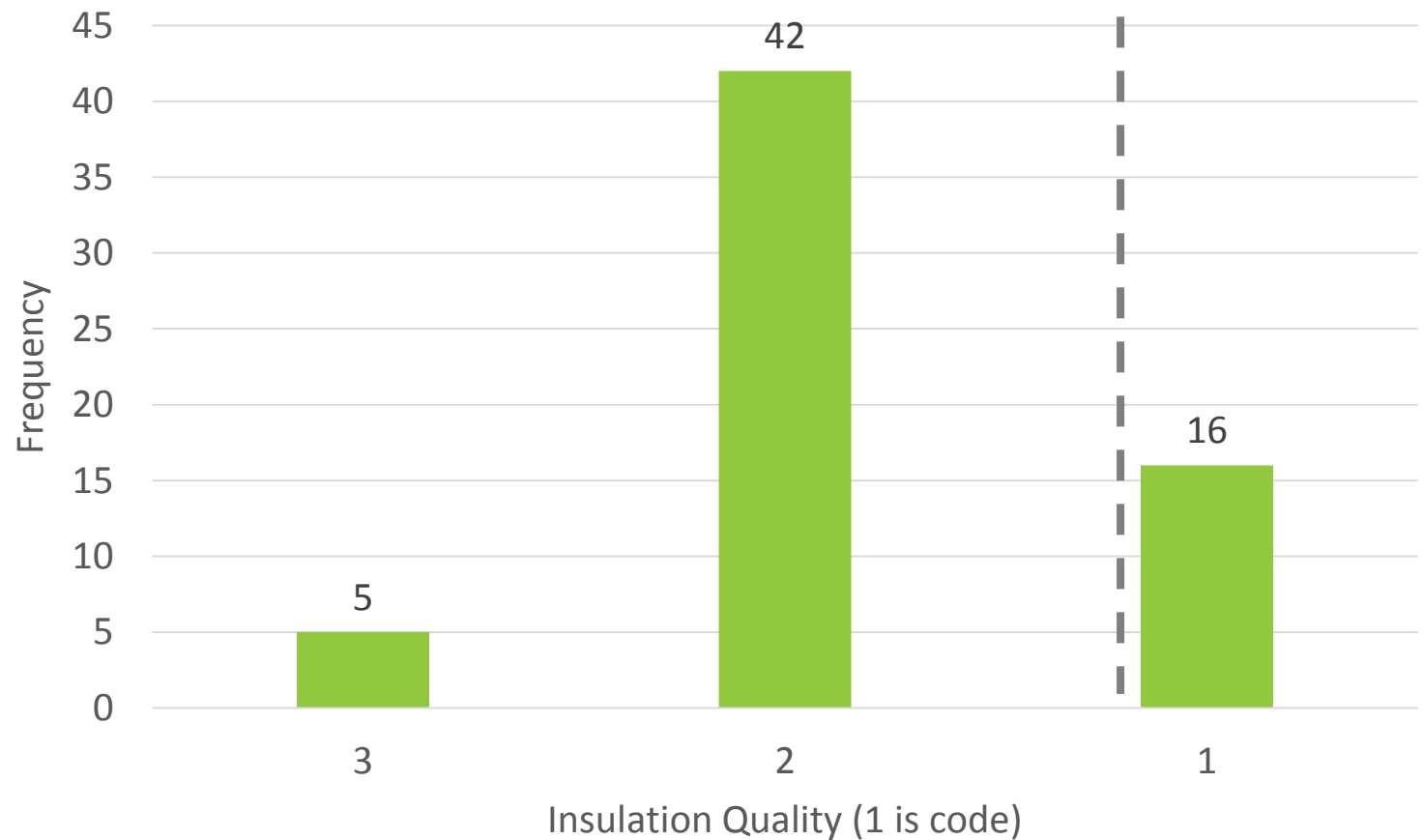
# Exterior Wall Insulation

*R-Value*



# Exterior Wall Insulation

## *Insulation Quality*



# Insulation Quality

*Level 1 = Code*



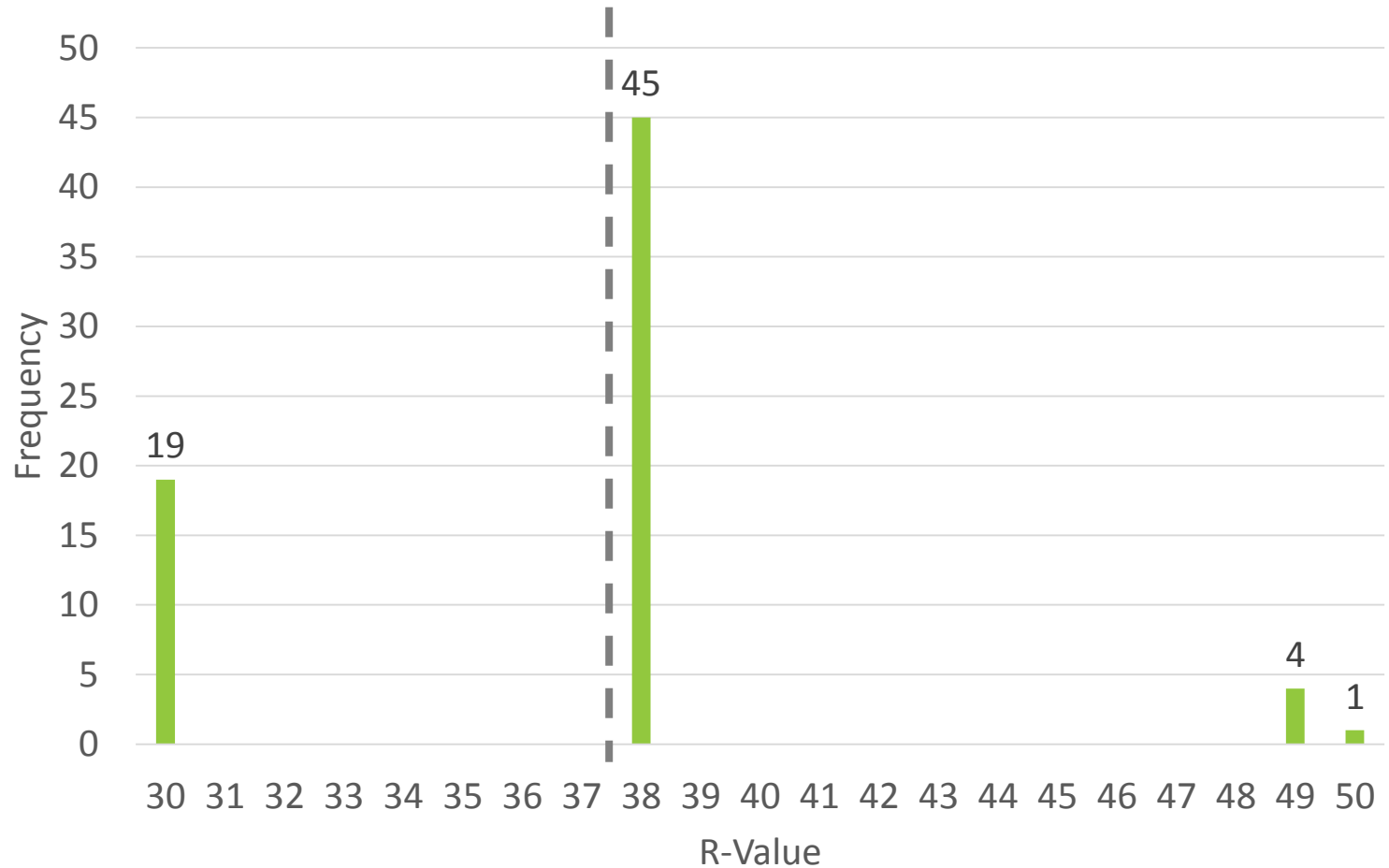
# Insulation Quality

*Level 3 = Not Code*



# Ceiling Insulation

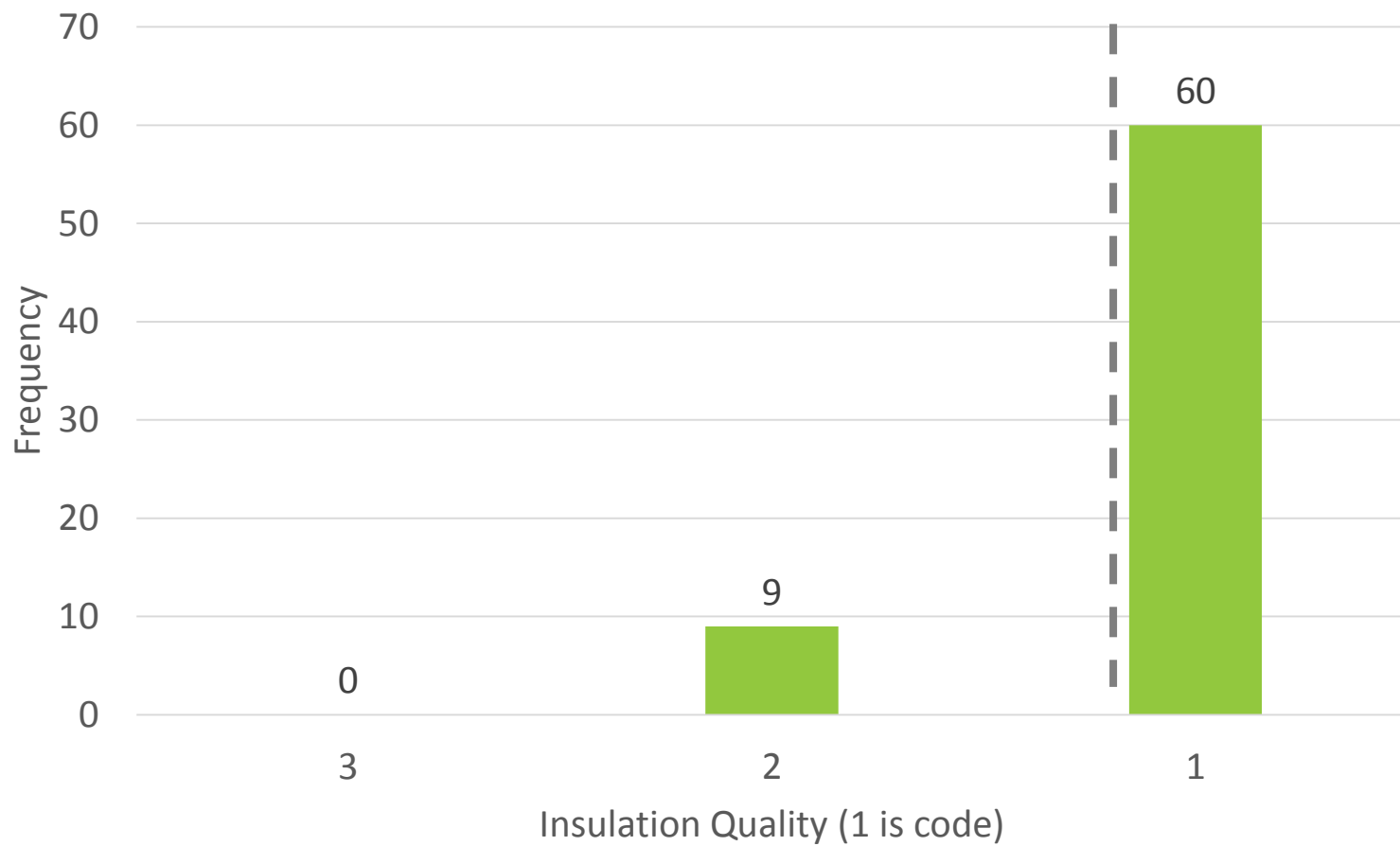
*R-Value*



Code Requirement: R-38 min.

# Ceiling Insulation

## *Insulation Quality*



# Bonus Information!

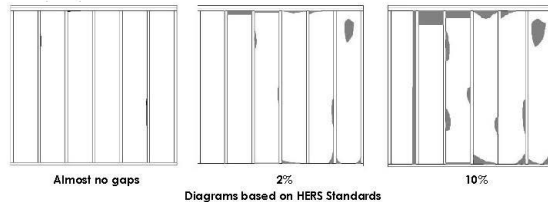
## Insulation Quality Guide

### Is the insulation up to code?

When insulation installation is evaluated, assemblies are often designated as Grade I, Grade II, or Grade III. Two criteria are considered when determining the installation grade: missing insulation and compression. **Grade I is used to describe insulation that is generally installed according to manufacturers' instructions (Section 303.2 2009 IECC) and therefore is the only grade considered to be code compliant for the prescriptive path.**

#### Missing Insulation

- **Grade I\***: 0% to 0.5% of the area, or up to 7 sq. in. of missing insulation per stud bay
- **Grade II\***: 0.5% to 2% of the area, or 7 square inches to 27 sq. in. of missing insulation per stud bay
- **Grade III\***: More than 2% of the area, or more than 27 sq. in. of missing insulation per stud bay



#### Compression\*\*

- **Grade I\***: Up to 2% compressed area (27 sq. in. per stud bay), must be >70% of the intended depth
- **Grade II\***: Up to 10% compressed area (133 sq. in. per stud bay), must be >70% of the intended depth
- **Grade III\***: A total compression area of more than 10%, (or more than 133 sq. in. per stud bay)

\* Suggested ranges based on RESNET guidelines. Area calculations are based on an 8 ft. ceiling with 16 in. stud bays.

\*\* The Insulation Institute allows insulating stapling but it is not recommended here since it reduces the R-value of the wall.

#### Why is having properly installed insulation important?

Gaps, voids, and compressions can cause cold spots in walls, ceilings, and floors. In addition to the loss of insulating value (and increased heating / cooling expense), these cold spots can cause drafts and encourage the formation of condensation in the wall cavity, floor, or ceiling.

#### Challenges and Code Compliance

It's often immediately clear whether insulation installation is Grade I or Grade III. The difficulty often comes when distinguishing between I and II (**Grades II and III are not code compliant**). That's when a closer look is necessary. Is the batt split around wiring / piping and cut tightly around switches / receptacles, do compressions reduce thickness to <70%, is the total area of missing insulation >0.5%? In other words you need to carefully assess if the sum total of imperfections leads to a Grade I or Grade II determination.

#### Helpful Resources



<http://bit.ly/departmentofenergy>



<http://bit.ly/insulationinstituteTips>



<http://bit.ly/owenscorninggrade1>



### Examples from the field



**Grade I: Compliant**



**Grade II: Not Compliant**



**Grade II: Not Compliant**



**Grade I: Compliant**



**Grade III: Not Compliant**



**Grade III: Not Compliant**



**Grade I: Compliant**

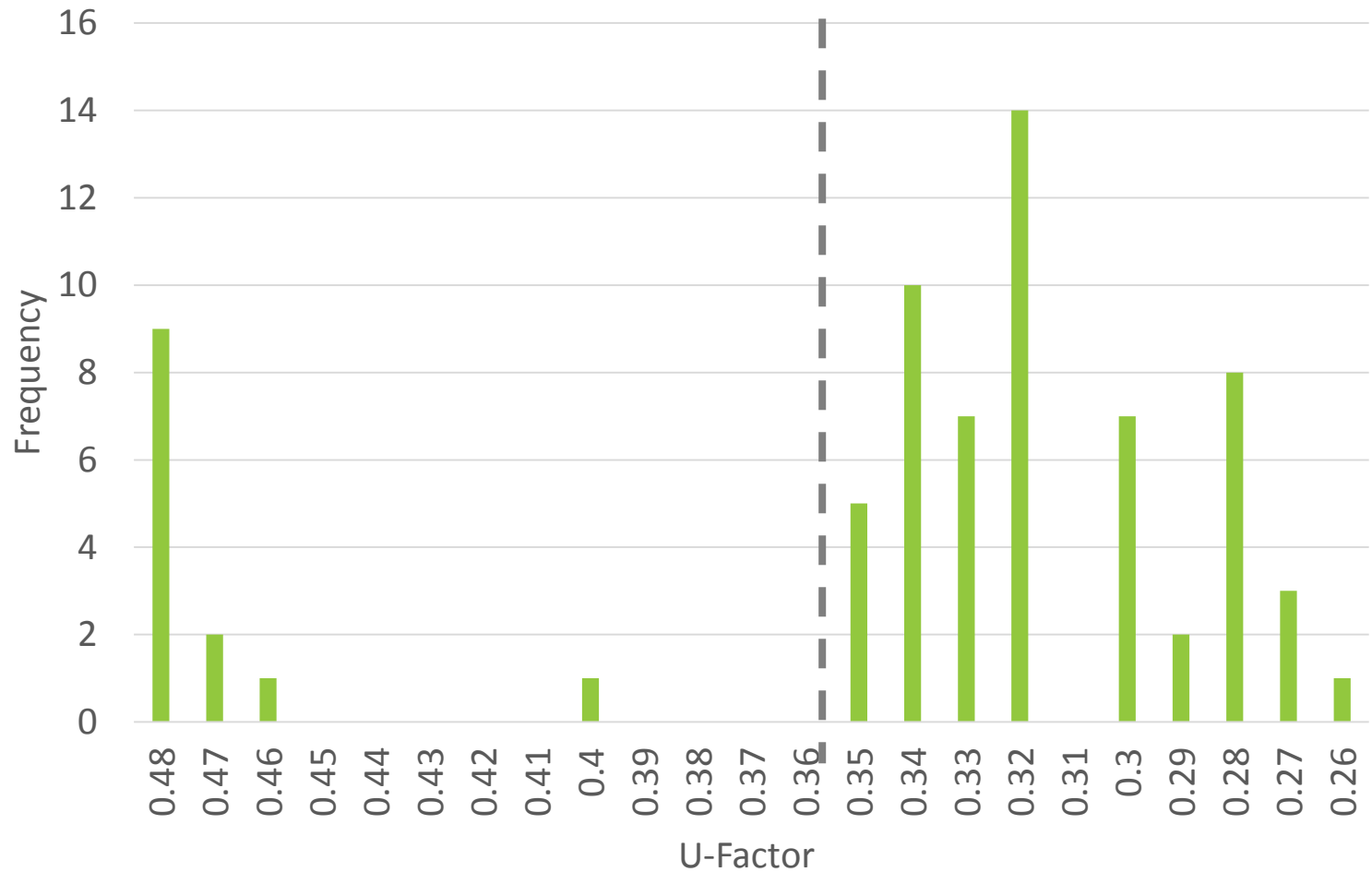


**Grade I: Compliant**

[bit.ly/Insulation\\_Guide](http://bit.ly/Insulation_Guide)

# Window Efficiency

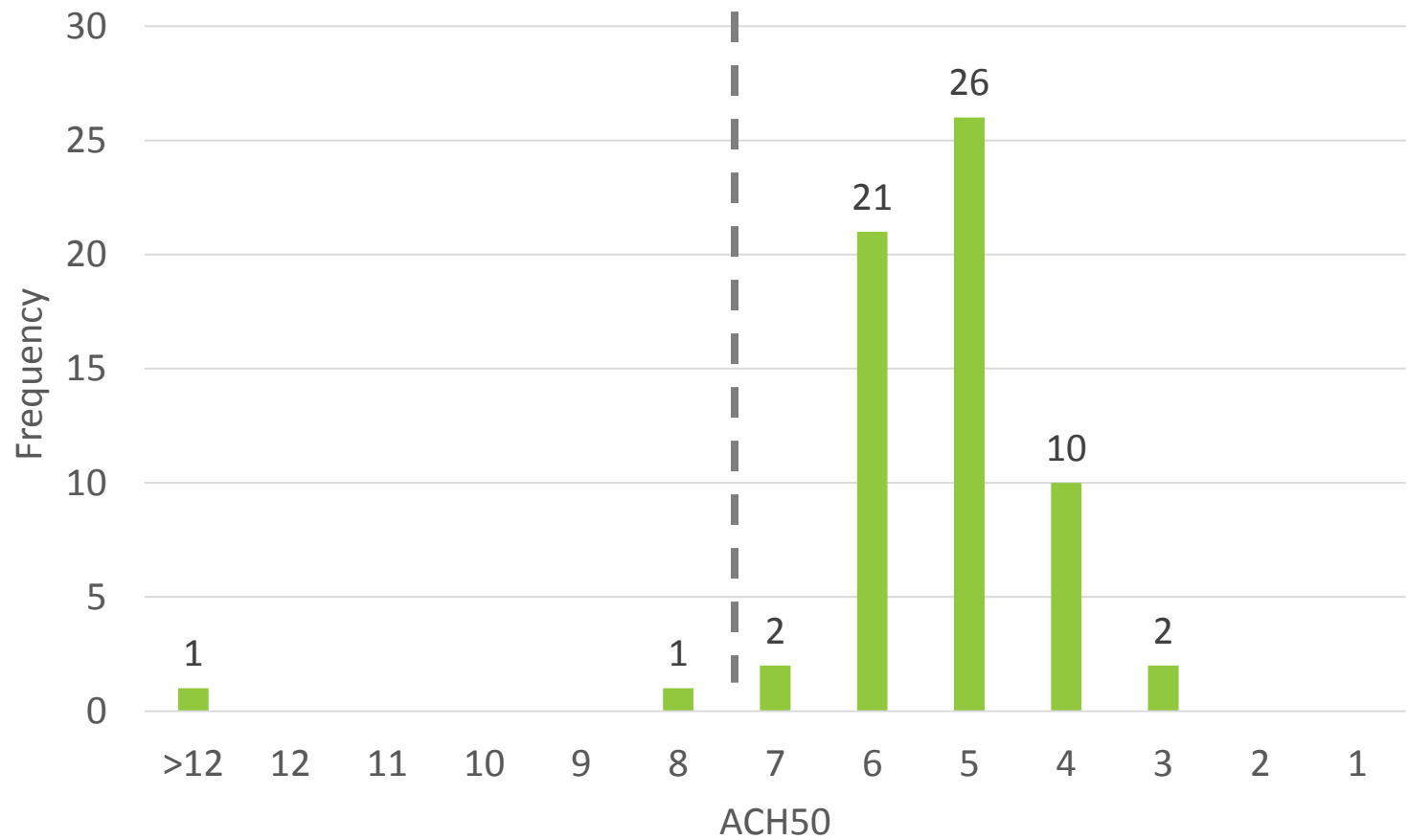
*U-Factor*



Code Requirement: U=.35 max.

# Air Sealing

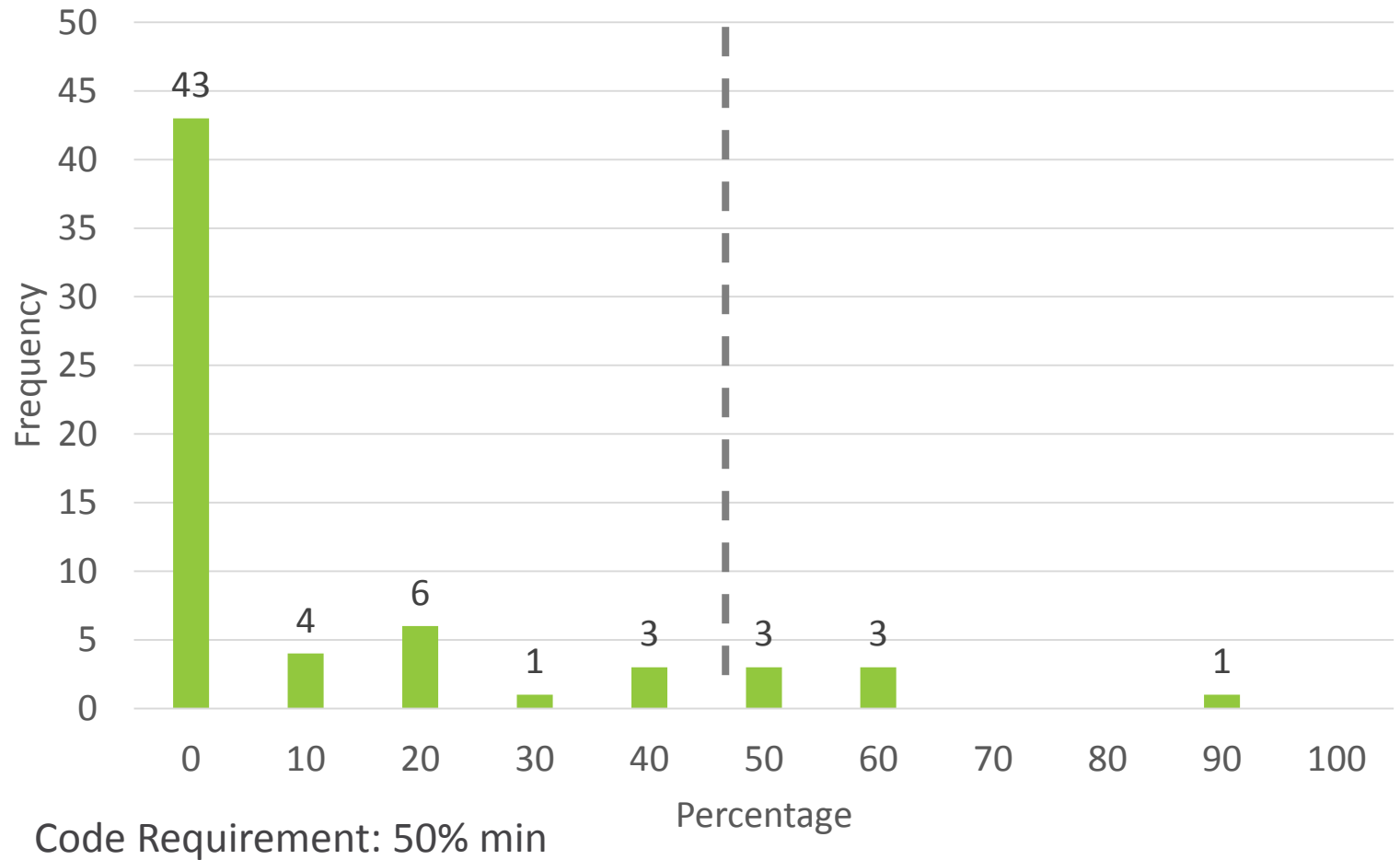
## Leakage Rate (ACH50)



Code Requirement: 7 ACH50 max

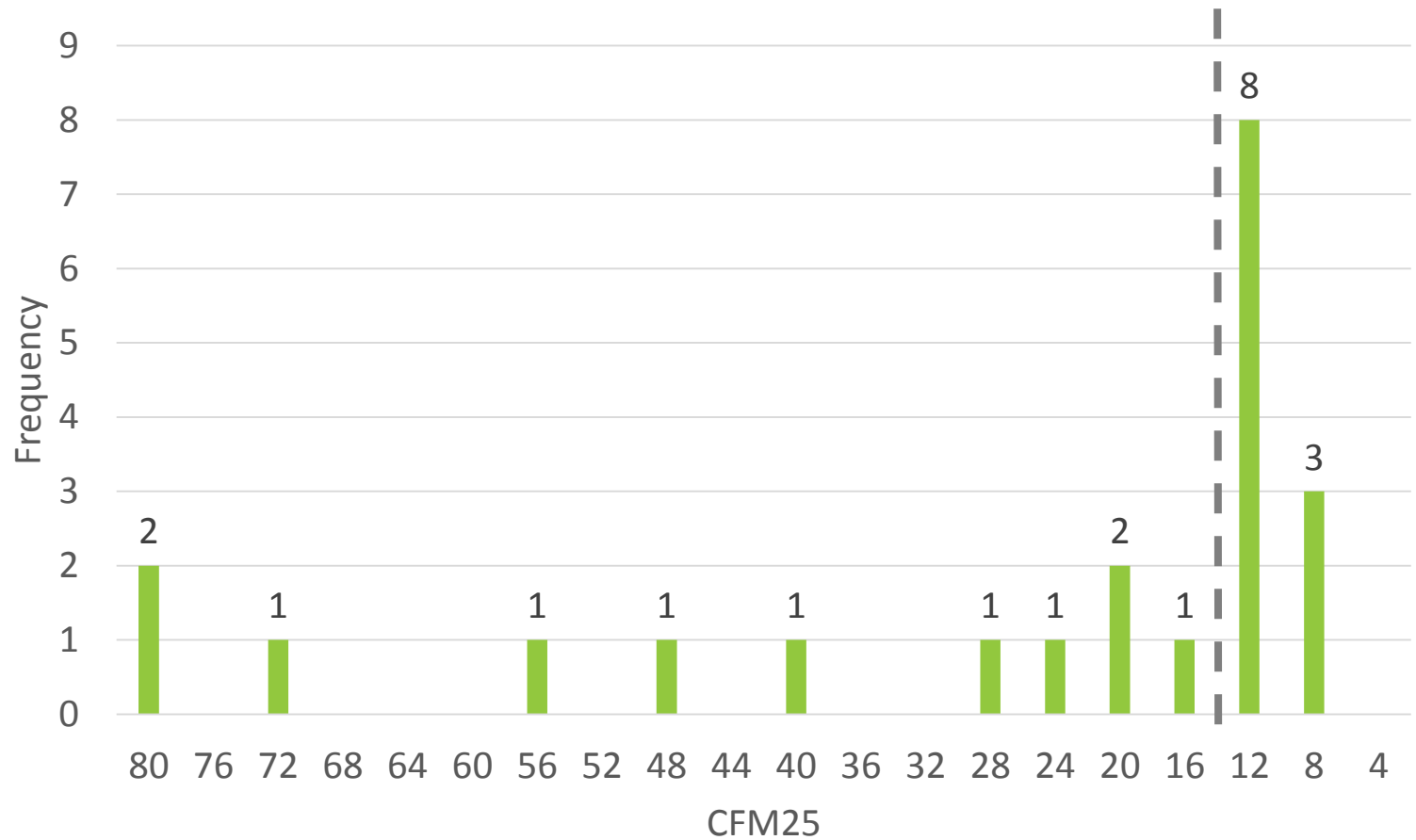
# Lighting Efficacy

## High Efficacy Lighting (%)



# Duct Leakage – Unconditioned Space

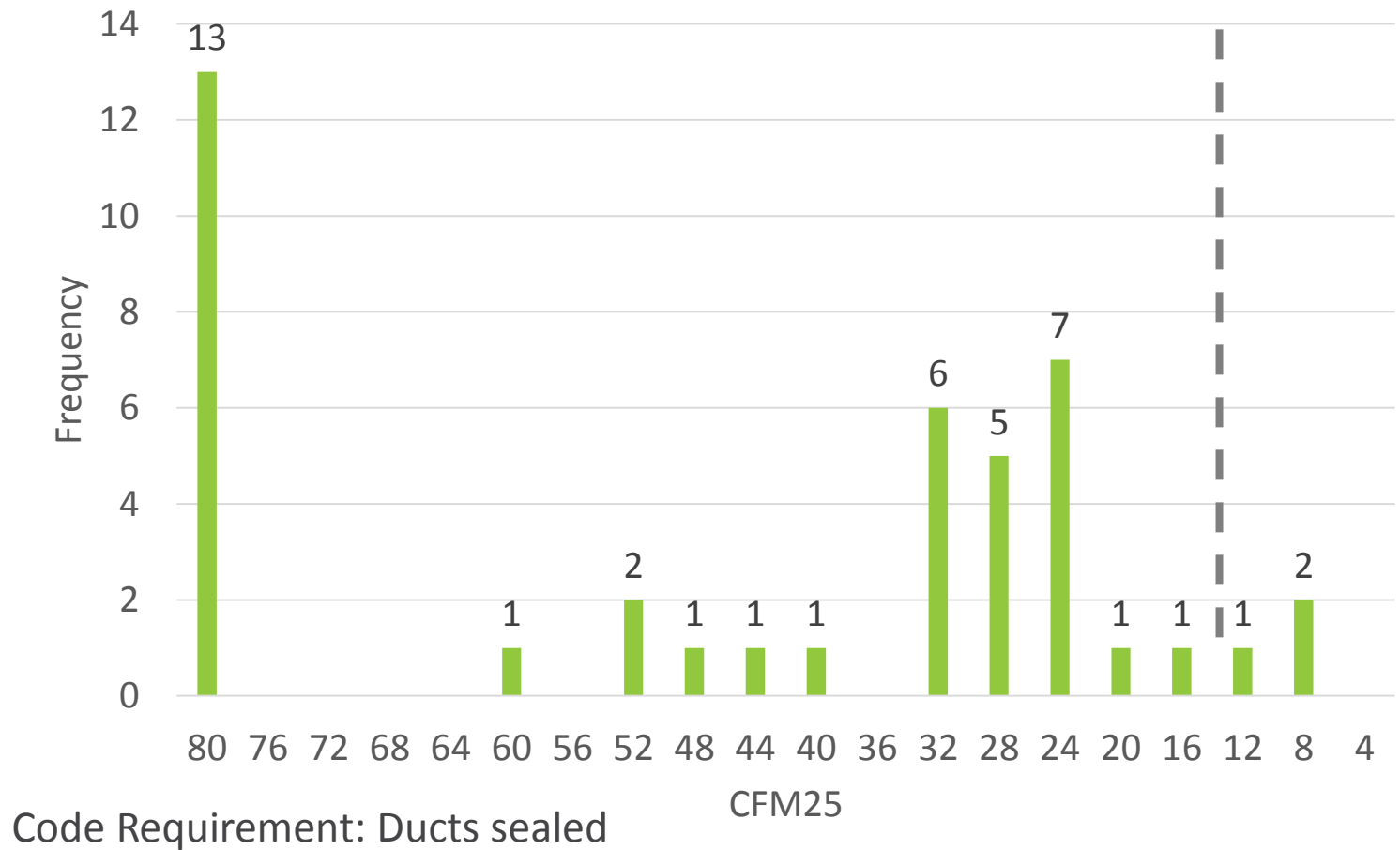
*Duct Leakage (CFM25)*



Code Requirement: 12CFM25 max

# Duct Leakage – Conditioned Space

*Duct Leakage (CFM25)*



# Potential Energy Savings

## Measure Level Savings

Measure	Electricity Savings (kWh at meter)	Natural Gas Savings (therms)	Energy Savings (MMBtu)	Electricity Savings	Natural Gas Savings (dollars)	Energy Cost Savings (dollars)
Basement Wall Insulation	732,822	847,765	87,277	\$89,990	\$971,746	\$1,061,737
Duct Leakage	3,706,493	400,964	52,743	\$455,157	\$459,603	\$914,760
Lighting Efficacy	4,830,095	-64,040	10,076	\$593,136	\$-73,405	\$519,731
Wall Insulation	1,624,312	203,688	25,911	\$199,466	\$233,476	\$432,942

Fuel Prices		
Electricity	0.12	\$/kWh
Natural Gas	1.15	\$/therm

# Homes	
CZ4	10,061
CZ5	278



# Potential Energy Savings

## Measure Level Savings

Measure	Electricity Savings (kWh at meter)	Natural Gas Savings (therms)	Energy Savings (MMBtu)	Electricity Savings	Natural Gas Savings (dollars)	Energy Cost Savings (dollars)
Window U-Factor	329,806	75,268	8,652	\$40,500	\$86,276	\$126,776
Ceiling Insulation	222,191	21,867	2,945	\$27,285	\$25,065	\$52,351
<b>TOTAL</b>	<b>11,445,719</b>	<b>1,485,512</b>	<b>187,604</b>	<b>\$1,405,534</b>	<b>1,702,761</b>	<b>\$3,108,297</b>

Fuel Prices		
Electricity	0.12	\$/kWh
Natural Gas	1.15	\$/therm

# Homes	
CZ4	10,061
CZ5	278



## HVAC Analysis Methodology

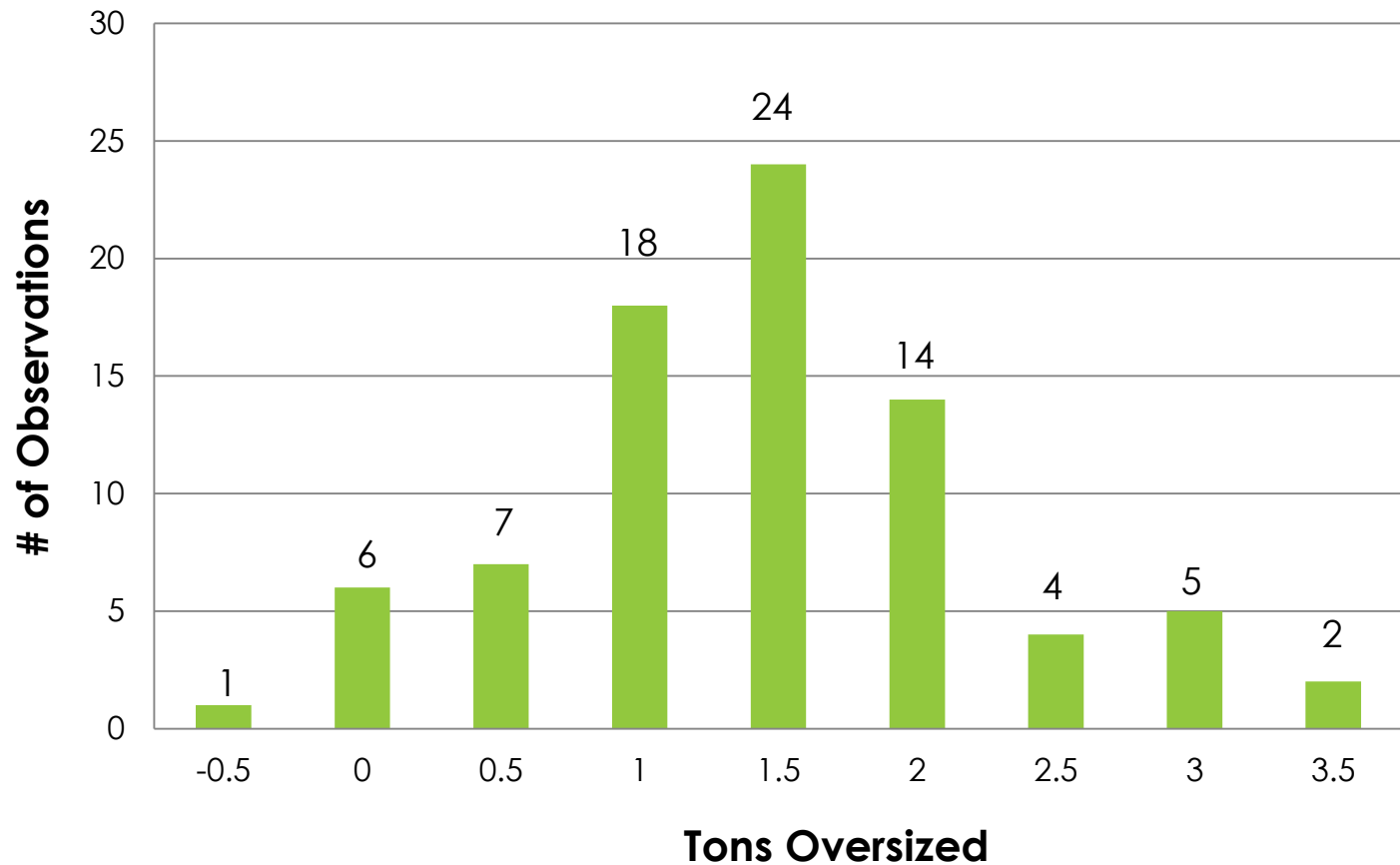
- Methodology\* was designed to determine if the AC system was appropriately sized (ACCA Manual J) for the home as constructed\*\*
- Each home was individually modeled, the building load calculated, and the maximum design size for the unit calculated
- The design size was then compared to the size of the unit actually installed
- PNNL also calculated the demand savings associated with the non-compliant key items

\* This is an exploratory analysis. It does not carry the statistical significance of the key item analysis

\*\*See <http://www.mwalliance.org/sites/default/files/media/More-Bang-for-the-Buck-Final.pdf>

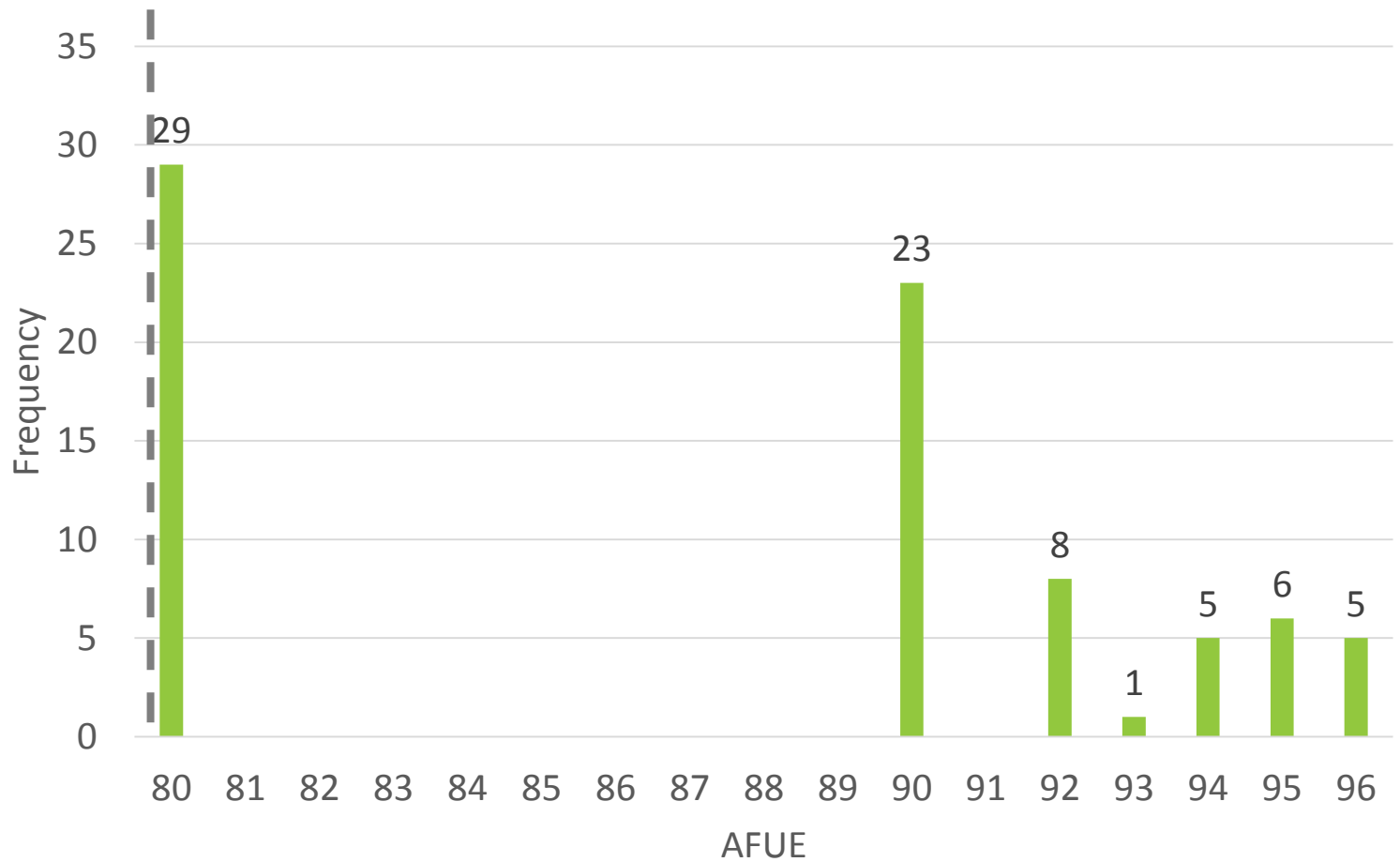
# Installed AC Units

## *Tons Oversized*



# Furnace Efficiency

AFUE



Code Requirement: 80 AFUE

# Potential Electric Demand Reduction

*kW Potential Savings*

Measure	Potential Electric Demand Reduction (kW)
AC Right Sizing	2,497
Lighting Efficacy	1,390
Exterior Wall Insulation	1,250
Basement Insulation	690
Window U-Factor	310
Duct Leakage	210
Ceiling Insulation	170

# Range of kW Savings

## *Interactive Effect*

- Impact of kW interactive effects is not known (PNNL internal study found little interactive effect for kWh/therms)
- Annual Savings
  - Low Range: ~3,500 kW
  - Mid Range: ~4,500 kW
  - High Range: ~6,500 kW

# Compliance Rate

*Trickier Than You Think*

- This study was designed to determine potential savings due to non-compliance
- Study focused on *key items* – it did not assess every code requirement
- Savings are incremental, but compliance is binary – either you comply or you don't
- DOE is focused more on savings opportunities than straight compliance rate

# Compliance Rate

*Trickier Than You Think*

- A weighted key item analysis was used to determine a compliance rate
- Weighting determined by measure impact on modeling software (REMrate)
- Weighting factor x measure compliance = weighted compliance
- Sum of weighted compliance measures equaled ~65% compliance rate



# Break Time!



# Implications of Analysis

*There is an opportunity here*

- Analysis only included single family homes – specific non-compliance in other building types should not be inferred
- Significant opportunity for kWh, therm, and kWh savings
- Results provide ability to design a compliance support program that targets high value measures
- Key item analysis results are statistically significant (in statistician language), but only on a statewide level
- AC sizing results do not carry the same statistical significance (# of observations required for statistical significance has not been determined)

# Opportunities for Collaboration

*What do we do with all this information?*

- DED/DE letter to DOE (ARRA reporting requirement) will likely suggest a few ideas for improving compliance and capturing savings
  - Collaborative
    - Regular gathering of stakeholders to discuss compliance issues and initiatives in a neutral setting
  - Circuit Rider
    - Pro-active outreach and support for code officials and builders
  - In-Person Training
    - Focused on identified non-compliance issues
    - Explains the “why” behind code requirements
  - Online Resources
    - How-to videos, guides, checklists, blogs, links, etc

# Opportunities for Collaboration

*What do we do with all this information?*

- Information coming in from other states
  - DOE States
- What some other utilities are doing
  - Cedar Falls (IA): Manual J
  - Excel (CO): Branding
  - Illinois: Proposal for full residential and commercial compliance support program

# Opportunities for Collaboration

*What do we do with all this information?*

**Now it's your turn!**

What do we do with all this  
information?

What are the opportunities for  
collaboration?

# Contact Information

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